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Scheduling and Optimization of Traffic Lights in Vanet

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ABSTRACT
With the advent of various advances in vehicles, traffic congestion is a serious problem in big cities. With the number of vehicles increasing rapidly, especially in cities, the situation is getting even worse. Traffic lights are used to control the flow of traffic, which can help peoples to reach their destination without any unnecessary delay of traffic Congestion at cross road. Currently, fixed cycle traffic light system manages traffic, throughput of traffic decreases at intersections during rush hours. Hence, an Adaptive traffic light scheduling system is proposed here. This system dynamically changes the cycle of traffic lights according to current traffic, and even the scheduling scheme is modified for avoiding unnecessary delay. Advances of Vehicles led to vehicular communication through Vehicular Ad hoc Network (VANET). Communication between Vehicle to Vehicle and Vehicle to Infrastructure is now possible. In this proposed approach, real-time speed and position information is aggregated from individual vehicles to improve traffic flow at intersections (crossroads), so that, vehicle can travel with minimum delay. Various scheduling algorithms are compared with respect to platoons of vehicles. The main goal is to reduce average delay, fuel consumption and air pollution. This would eventually reduce the Drivers Fatigue.

Keywords: VANET, Adaptive Traffic Flow, Non-Adaptive Traffic Flow, Average Delay, OBU, RSU

Introduction

Vehicular Ad-Hoc Network (VANET) is a form of ad hoc network that provides communication between vehicles (OBU-On Board Unit) and between infrastructure (RSU-Road Side Unit) and vehicles (OBU). Researchers have significantly contributed to achievements in VANET, and necessary solutions have been suggested. The Intelligent Transportation System (ITS) is an important application of VANET among other applications. In a VANET environment, these devices are enabled with On-Board Units (OBUs) or access points (APs) strategically located in fixed points along the road, they are referred to as Road Side Units (RSUs) [1].

High mobility of vehicles creates major issues for traffic handling. Traffic management is an application of VANET. High dynamics of vehicles combined with usage of short range communications make the connectivity among the vehicles very unstable, so even the best effort service cannot be guaranteed. City traffic and Highway traffic is completely different. Highway traffic requires different set of policies for traffic handling. VANET can be used for safety applications as a primary goal; for driving support information services (information about parking places, points-of-interest, etc.) and, in some places, it can offer classic internet services including high quality media streaming and voice or video calling. Some of the VANET projects [2] are AKTIV (Traffic Management, Active Safety, Cooperative Cars using cellular nets), AIDE (Integration of driver assistant sys- tem and nomadic devices), COM2REACT (Road traffic con- trol centre), COOPERS(Vehicle-to-infrastructure, traffic man- agement), COMeSafety, CVIS, CyberCars-2, DAIDALOS- II, eImpact, FRAME (Framework for national European ITS architectures), GST, INTERSAFE-I (PReVENT), i-Way, MORYNE, NoWNetwork on Wheels, PReVENT (Reliable and secure communication for safety and infotainment), REPOSIT, SAFESPOT (Vehicle-to-vehicle communication, road safety, local dynamic map), SeVeCom, Watchover, WILLWARN (PReVENT)(Emergency warnings based on wireless com- munication) [1][2]. Figure 1 shows various applications of VANET.

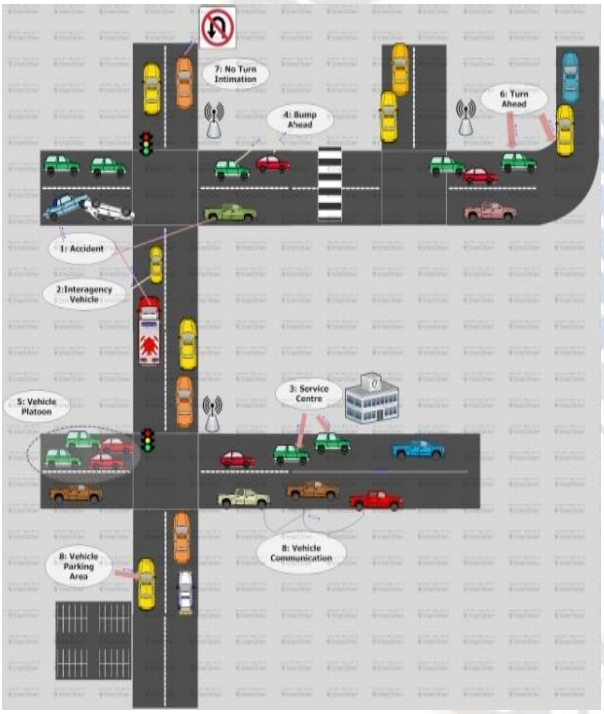

Fig. 1. VANET Applications

Related Work

Researchers are working on different approaches of Intelligent Traffic System. Focus is on Image Processing in VANET. Projects are in progress for improved safety in highways and comfort driving. Researchers have argued about optimization and feasibility of various approaches [7][8][9][10][17]. Image Processing approaches have some limitations in the heavy raining, foggy or sand storm weather and at very dark or unlined roads. If few parameters like drivers fatigue, dynamic nature of traffic, priority of vehicles etc. are ignored, VANET results may show remarkable performance improvement. In [17], researchers have tried to predict the traffic flow depending on time or Vehicle Queue Length only, that might help to solve the problem of traffic congestion and enhance the traffic flow. This scheme fails in some cases as they have missed other factors like congestion status in during previous traffic scheduling and congestion status of next traffic intersection. If these two criterions are considered, improvement in traffic flow is maintained. For VANETs, various criteria for traffic demand and variations and traffic control systems are to be considered.

Traffic Demands and Variations

Traffic demands can be distinguished into three category: Short term, Medium term and Long Term. If traffic considered is for 15 minutes or 30 minutes, it is treated as short term traffic. Temporal shift or spatial shift for different conditions of weather, incidents and holidays may be considered. Time span for traffic on daily basis and weekly basis for temporal conditions like constructions, and office hours are considered. Long span of time like annual and seasonal may be considered for newer developments and annual traffic growth [6].

Different Traffic Control System

Different categories of Traffic Control Systems are avail- able as follows [10]:
Fixed time traffic control systems: Based on history and regular usage of road, fixed schedule can be allocated to traffic signal. Schedule is decided based on time of day or day of week from a set of pre-determined plans developed on the basis of historical traffic data.

Responsive traffic control systems: Specific responsive system is designs which monitor the traffic. Appropriate signal timing plans are implemented. Signal plans are prepared off-line in advance
Pattern matching traffic control systems: Specific pattern is prepared based on flow of traffic. Also Timing plans updated based on measured traffic flows and semi-automated optimization methods and then loaded into the system database.
Adaptive traffic control system: In this system, traffic time is changing frequently. Based on different parameters, it changes frequently. It is on-line short term quick response without any kind of prediction.

Proposed System Architecture

In our proposed approach we try to reduce number of average number of halts for a vehicle and minimize total travel times in trips.

Assumptions

A centralized traffic control system is assumed to be in place. This centralized traffic control system will schedule the traffic lights in such a way that congestions in traffic at intersections are minimized. Through scheduling algorithm the total trip time can be reduced. Components of given system are On Board Unit (OBU), Road Side Unit (RSU), Traffic Light (TL) and Control Centre (CC). System has knowledge of road structure, number of lanes, cross roads and various types of vehicles. GPS unit connected with OBU provides current position details TL. Through vehicle to vehicle and vehicle to infrastructure communication, TL gathers necessary information. Work of OBU is to send current position details to other OBU and nearest RSU. Every cross road is assumed to be enabled with RSU; where each RSU is connected with each other. Communication range of RSU and OBU can differ based on type of road. TL is connected with RSU. Based on the number of vehicles, TL decides the time of signal. Also TL is connected with each other and decides the relevant timing for consecutive TL. It is assumed that the vehicle travel time based on predictive method. We also consider other parameters like driver fatigue, dynamic nature of traffic, need of priority for specific vehicle etc. Architecture of proposed system is as shown in Figure 2.

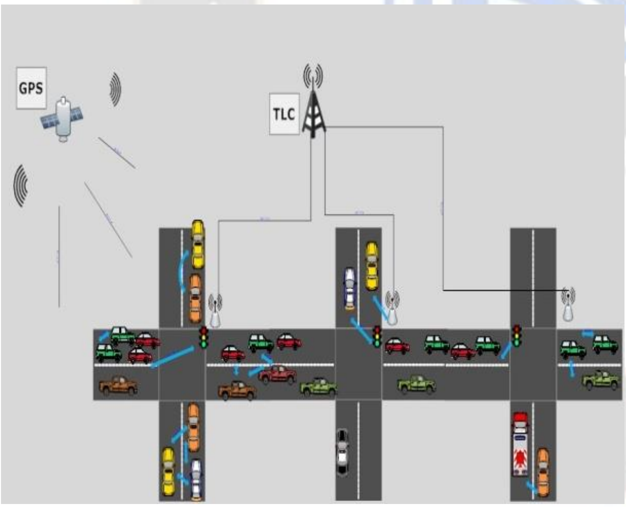

Fig. 2. Proposed Approach

CC can work as a central authority, responsible for collecting details from TL and analyze the data. Scheduling algorithms and various traffic prediction techniques can be implemented here. Based on data analysis, information is distributed to TL, which generates the traffic signal time for minimum delay.

Proposed Algorithms

[A] Static Predefined Traffic light scheduling

In this traffic light scheduling all the junction traffic lights are enabled with predefined timings. This scheduling is similar to the existing pre timed scheduling.

Step 1: JN_i (i^{th} Junction Node) indicates intersection on the road and TL_i (i^{th} Traffic Light) indicates the selected traffic light of particular JNi on the road;
Step 2: Traffic Light system started on Traffic signal. $TL_i \leftarrow$ ON ;
Step 3: Assign specific value to each Junction (JNi) by calculating TLi;
Step 4: Each side traffic will get time T=150 Seconds. For each TL_i set, Each Side have to wait for RT seconds and Traffic will be released for total time of GT+YT.

T=150 Seconds; P=30 Seconds;
RT= 3*T;
GT= T-P;
YT= P;
Step 5: Exit;

[B] Vehicle Based Actuated Traffic light Scheduling

In this traffic light scheduling if there are no vehicles at the intersection then the traffic light of that intersection will remain off for that particular time.

Step 1: JN_i (i^{th} Node Junction) indicates intersection on the road and TL_i (i^{th} Traffic Light) indicates the selected traffic light of particular JN_i on the road;

Step 2: Traffic Light system started on Traffic signal. $TL_i \leftarrow$ ON;
Step 3: For each JN_i set TL_i;
Step 4: If any vehicle enter into the coverage of particular TL_i, Vehicle will register its VID to TL_i.
$TL_i \leftarrow$ VID;
Step 5: IF JN_i (TL_i) = TRUE then

{$TL_i \leftarrow$ ON;
T=150 Second; P=30 Second;
RT= 3*T; GT= T-P; YT= P;

}
else $TL_i \leftarrow$ OFF;

End if;

Step 5: Exit.

[C] Shortest Platoons First Traffic light Scheduling

In this traffic light scheduling all the vehicle communicate with roadside infrastructure and each roadside infrastructure are connected with control centre. Then CC will schedule traffic lights as per size of platoons.

Step 1: JN_i (i^{th} Node Junction) indicates intersection on the road and TL_i (i^{th} Traffic Light) indicates the selected traffic

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light of particular JN_i on the road;
Step 2: Every road junction is connected with RIU (Roadside Infrastructure Unit) and each RIU is connected with CC (Control Centre).
Step 3: Traffic Light system started on Traffic signal TL_i ← ON;

Step 4: For each JN_i, set TL_i;
Step 5: Each vehicle when entered into the coverage of particular RIU_i. vehicle will register its Vehicle ID(VID) and Vehicle Current Location (VLoc) to RIU_i.

RIU_i. ← {VID, VLoc}

Step 6: RIU will collect all the data and make the platoons of vehicles using $VLoc_i$ of vehicles and send it to the CC;
CC ← RIU;

Step 7: CC will schedule each TL_i as the shortest platoon first and according to the size of platoon, it will set the TL_i at each JN_i;
TL_i ← Scheduled_Data {CC}

Step 8: If two platoons are having same size then scheduling will be performed on FCFS (First come first serve) basis;
Step 9: IF JN_i (RIU) = TRUE then

{ TL_i ← ON;
GT= (F * N) seconds;
YT= (F / 4) seconds;
RT= (F * TON) seconds;

}

Else
TL_i ← OFF;

End If;

Step 9: Exit.

Here F is the minimum average time required for one vehicle to cross the intersection, N is the number of vehicles in a particular platoon at TL_i of intersection JN_i. TON indicates the total number of vehicles at intersection JNi at time T.

[D] Multiple Queue based Traffic light Scheduling

In this traffic light scheduling all the vehicle communicate with roadside infrastructure and each roadside infrastructure are connected with control centre. The control centre will use multiple queue like lower level, medium level and higher level queue. In this emergency vehicles are always get higher priority compare to other vehicles.

Step 1: JN_i (i^{th} Node Junction) indicates intersection on the road and TL_i (i^{th} Traffic Light) indicates the selected traffic light of particular JN_i on the road;

Step 2: Every Road junction is connected with RIU (Roadside Infrastructure Unit) and each RIU is connected with CC (Control Centre);

Step 3: Traffic Light system started on Traffic signal. TL_i ← ON;

Step 4: For each JN_i set TL_i;
Step 5: Each vehicle when entering into the coverage of particular RIU_i, vehicle will register its Vehicle ID (VID) and Vehicle Current Location (VLOC) to RIU_i.

RIU_i. ← {VID, VLoc}

Step 6: RIU will collect all the data and make the platoons of vehicles using $VLoc_i$ of vehicles and send it to the CC;
CC ← RIU;

Step 7: CC will schedule each TL_i;
Step 8: If vehicles data is received at RIU_i of particular JNi then
TL_i= ON;
Else
TL_i= OFF;
Step 09: Initially CC will keep all the traffic lanes into lowest level queue.
Step 10: CC will do the scheduling based on N(Veh) which indicates number of vehicles and X_i indicated minimum threshold value for i^{th} lane.
If N(Veh) > X_i Then

The lane is shifted to NEXT higher level queue;
End if:

If N(Veh) <= X_i Then

The lane remains in the lowest level queue;

End if;

If Veh(Emergency)=TRUE then
The lane is shifted to the highest level queue.
End if:

Step 11: CC checks if multiple lanes are in the highest level; if so, they are served according to the FCFS basis
Step 12: CC will serve queue according to their level and on each level the lanes are served as per RR scheduling

Step 13: IF TL_i=ON; Then
Set TL_i
GT← (F * N) seconds;
YT← (F / 4) seconds;
RT← (F * TON) seconds;
Where F indicates minimum average time required for one vehicle to cross the intersection. N indicates number of vehicles into particular platoon at TL_i of intersection JN_i. TON indicates the total number of vehicles at intersection

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JN_i at time T.
Step 14: Exit.

[E] Multiple Queue based Traffic light Scheduling with Factor D

This scheduling scheme is similar to the above. But this would be of significant to the drivers benefit because in this driver fatigue is considered as factor D.

Step 1: JN_i (i^{th} Node Junction) indicates intersection on the road and TL_i (i^{th} Traffic Light) indicates the selected traffic light of particular JN_i on the road;
Step 2: Every road junction is connected with RIU (Roadside Infrastructure Unit) and Each RIU are connected with CC (Control Centre);

Step 3: DFC indicates driver fatigue counter;
Step 4: A vehicle when starts travelling at that time DFC will be initialized by 0
Step 5: Traffic Light system is started on Traffic signal. $TL_i \leftarrow$ ON;

Step 6: For each JN_i set TL_i;
Step 7: Each vehicle when entered into the coverage of particular RIUi, vehicle will register its Vehicle ID (VID), Vehicle Current Location (VLoc) and DFC to RIU_i.

RIU_i. ← {VID, VLOC, DFC}

Step 8: RIU will collect all the data and make the platoons of vehicles using $VLoc_i$ of vehicles and send it to the CC.
CC ← RIU;

Step 9: CC will schedule each TL_i;
Step 10: IF vehicles data received at RIU_i of Particular JN_i then
$TL_i \leftarrow$ON ;
else
$TL_i \leftarrow$OFF ;
End If;

Step 11: Initially CC will keep all the traffic lanes into lowest level queue.
Step 12: CC will check total number of vehicles with DFC reached to the threshold value (TH_{dfc}) into each lane.
Step 13: CC will do the scheduling based on N(Veh) which indicated no. of vehicle, X_i indicated minimum threshold value for i^{th} LAN and Y_i indicates threshold value for Driver Fatigue.
If N(Veh) > X_i Then

The lane is shifted to NEXT higher level queue;
End if:

If N(Veh) <= X_i Then
The lane remains into the lowest level queue.
End if:

If Veh(Emergency)=TRUE then
The lane is shifted to the highest level queue.
End if:

IF $TH_{dfc} > Y_i$ Then
The lane is shifted to NEXT higher level queue.
End If;

Step 14: CC checks if multiple lanes into highest level then they served according to the FCFS
Step 15: CC serves queue according to their level and on each level the lanes are served as per RR scheduling

Step 16: IF TL_i = ON Then
Set TL_i
GT← (F * N) seconds;
YT← (F / 4) seconds;
RT← (F * TON) seconds;
Where F indicates minimum average time required for one vehicle to cross the intersection. N indicates number of vehicles into particular platoon at TL_i of intersection JN_i. TON indicates the total number of vehicles at intersection JN_i at time T.
Step 17: If vehicle get RT at particular JN_i then
Set DFC←DFC + 1;
End If;
Step 18: Exit.

Analysis of proposed approaches

In Static Predefined Traffic light scheduling approach used pre-stored signal timing plans calculated off-line, based on historical traffic data, in the same way as the existing control strategies. The selected timing plan is static. In Vehicle based actuated traffic light Scheduling uses both vehicle information and a set of control parameters to operate the intersection in a more efficient way. With the use of actuated traffic light Scheduling, intersection approaches are allocated green times based on their current demand. If there is no demand at intersection , then the traffic signal will be off. In Shortest Platoons First Traffic light Scheduling uses both Roadside infrastructure information and a set of control parameters to operate the intersection in a more efficient way. With the use of actuated traffic light Scheduling, intersection approaches are allocated green times based on their current demand. If there is no demand at intersection , then the traffic signal will be off. In this method the control centre collect all the data from platoons of vehicles. Multiple Queue based Traffic light Scheduling would be of significant benefit because of its ability to reduce delay times, travel times, number of stops, and vehicular emissions in response

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to the change in traffic patterns. The objective of this research is to develop an integrated adaptive algorithm that can be readily added to actuated traffic light Scheduling. This would provide a cost effective procedure to improve the performance of current traffic control systems without adding major cost to the system. This Multiple Queue based Traffic light scheduling with Factor D approach consists of all the characteristics of Multiple Queue based Traffic light Scheduling and it would be of significant to the drivers benefit because in this driver fatigue will be also considered as factor D. Comparison of Proposed approach with respect to various parameters are as below.

TABLE I. ALGORITHM COMPARASION

Algorithm	A	B	C	D	E
Nature	Static	Dynamic	Dynamic	Dynamic	Dynamic
Scheduling Dependency	Predefined Traffic	Depends on Vehicle	Depends on platoons of Vehicle	Depends of Type of queue in which vehicle lane resides	Depends of type of queue vehicle lane resides and Driver Fatigue
Complexity	Low	Low	Medium	High	High
Suitable Traffic for	Low	Medium	Medium	Heavy, Medium	Heavy, Medium
Processing at CC Side	NA	NA	Medium	High	High
Unnecessary Delay	High	High	Medium	Minimum	Minimum

Implementation Results

A. Simulator

Various Simulators are available in the market. We categories them into main three category: Mobility Generator Simulator, Network Simulator and VANET simulator which is a combination of mobility and network simulator. By comparing them we found suitable simulators are SUMO(Simulation of Urban MObility) as a Mobility generator and NS2.34 with 802.11P support selected as a network simulator. We also use MOVE for user friendliness.

B. Simulation Setup Scenarios

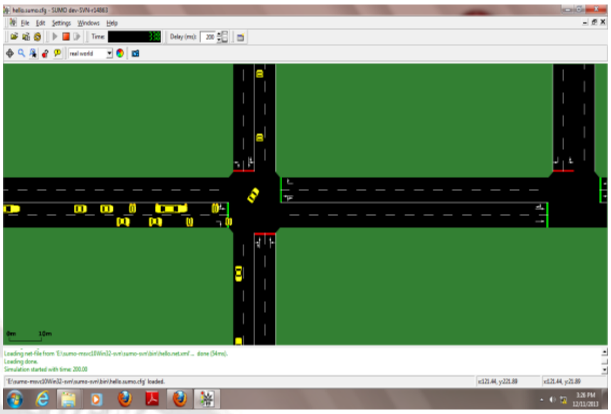

Fig. 3. Cross roads with Traffic signal

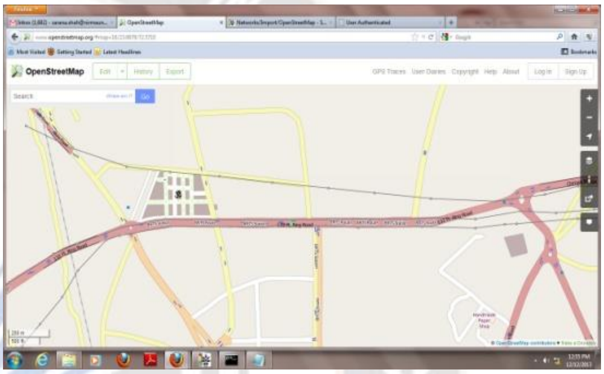

Fig. 4. Open Street Map of 132 ft Ring Road Ahmedabad City

Step 1: Manually create your own map nodes (hello.nod.xml)

Step 2: Manually create your own map edge (hello.edg.xml)

Step 3: Create map configuration file (hello.netc.cfg).

Step 4: Create Route configuration file(hello.rou.xml)

Step 5: Generate the Map file (hello.net.xml) using netconvert command.

Step 6: Simulation setup (hello.sumo.tr and hello.sumo.cfg)

Step 7: Visualize Simulation

Step 8: Generating Trace files using traceExporter utility.

Step 9: Simulated Multiple Cross roads with T-juction

Step 10: From the Mobility module of MOVE generate trace file(*.tr) and Traffic module of MOVE generate (*.tcl)

Step 11: Done the integration of NS2 with IEEE 802.11P

Step 12: Run the generated tcl in NS2.

Step13: Do the analysis of result for the proposed

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different approach by using different awk scripts.

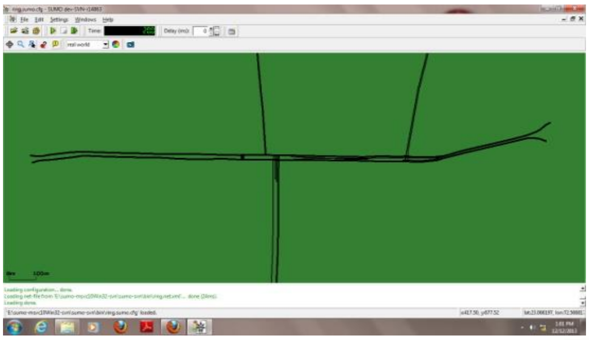

Fig. 5. Converted OSM map of Ring Road Ahmedabad City

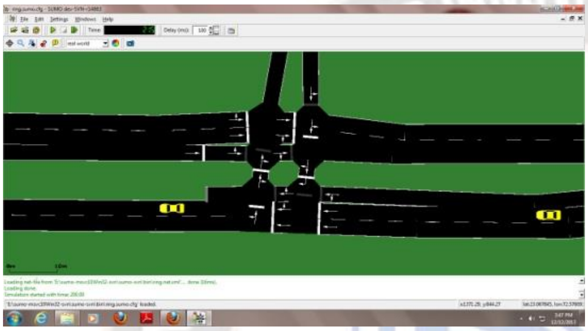

Fig. 6. Movement of vehicles on 132 ft Ring Road Ahmedabad City into SUMO

Conclusion

In this paper, different Traffic control system are covered and their applications related to traffic optimization are dis- cussed. Different approaches are proposed, for static predefined traffic light scheduling, Vehicle Based Actuated Traffic light Scheduling, Shortest Platoons First Traffic light Scheduling, Multiple Queue based Traffic light Scheduling, Multiple Queue based Traffic light Scheduling with Driver fatigue factor. In future, the same will be implemented in realistic scenario for Ahmedabad City Junctions and the implementation results will be analysed. SUMO and NS2 will be used for implementing the same and comparison based on their performance and scheduling optimization will be demonstrated.

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